CONTRIBUTIONS TO A KNOWLEDGE OF THE AUSTRALIAN CRUSTACEAN FAUNA.

No. i.—Observations on the Genus *Neptunus*.

By David G. Stead.

Though the observations contained in this paper have all been founded upon specimens of *Neptunus pelagicus*, M. Edw., they will be found to apply equally as well to the other species of this genus, *N. sanguinolentus*, excepting in a few minor details, such as the colour of the carapace, which in *N. sanguinolentus* is of a lighter hue, is only minutely granular, and possesses three large almost circular spots, somewhat similar to drops of blood, surrounded by bluish-white rings, one on either side, on the epibranchial regions, and one almost on the posterior border of the carapace, over the intestinal region. So, but for these slight differences, and a few others of small account, the two species may be said to be morphologically the same.

N. pelagicus is the most common of our pelagic Brachyura, being the principal edible crab of the Sydney Fish Markets. Incidentally I might mention that great numbers of these are sold every morning in these markets, with an occasional sprinkling of four other species, viz., *N. sanguinolentus*, *Scylla serrata*, *Charybdis cruciatus*, and *Platyonychus bipustulatus*.*

This species (*N. pelagicus*) is very abundant in Port Jackson, and, though usually captured by the fishermen in the nets, may also at times easily be caught with hook and line. When once possessed of a good grip of the bait they seem very loath to let go, thus enabling one to easily and effectually "land" them. It may be here stated that, in the procuration of the Brachyurous

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* See my "Notes on the Habits of some of the Australian Malacostracous Crustacea." "Zoologist," May, 1898.

Crustacea, I have always found that the best kind of bait is a large Chiton, deprived of its shell, of course. This being very tough, when attached to a large fish-hook, enables the crabs to gain a strong hold, without fear of the bait giving way. While in pursuit of these animals—especially *Grapsus variegatus*—I have sometimes witnessed a most ludicrous sight. When swinging the bait to and fro, like a pendulum, in some deep crevice of the rocks, arm after arm would be seen to shoot forth from every crack and cranny, as the bait passed along; some of the crabs even going so far as to spring out, in a wild endeavour to reach the coveted morsel.

The carapace, which is very wide, is drawn out on each side into a long acutely-pointed spine. In medium-sized and small specimens, as a rule, the carapace is covered with short dark setæ and very coarse granules; but in large examples these almost disappear (in some, both setæ and granules disappear altogether), and are much wider apart. This is worthy of note, inasmuch as some zoologists would, perhaps, be inclined to make a specific distinction, if it so happened that they could only procure the two varieties mentioned, especially as the coarsely granular kind has, as a rule, a more sombre uniform colour than the larger and smoother form, which generally exhibits a beautiful mottled appearance. This variation in colour especially claims our attention, as it is thought by some observers to be a distinguishing sexual mark, whereas it is not so, both varieties—with transitional forms—being found in each sex.

The anterior portion of the carapace, with the subhepatic and pterygostomial regions, is bordered with a dense margin of plumose sensory hairs.

As I have stated elsewhere ("Zoologist," May, 1898), the sexes at certain times seem to keep quite apart, and occasionally there may be seen scores of females with not one male amongst them, and *vice versâ*.

They seem to be of a very quarrelsome nature, as it is quite a common occurrence to find specimens minus part of a "nipper" or leg.

The spawning season is about August, September, October, and November. I have not up till the present time been able to gather sufficient data to enable me to say positively when it commences or terminates, but hope shortly to be in a position to state this with certainty. As might be expected, the species is of a predaceous, roving disposition, and is very widely disseminated. As in a great many other Brachyurans, so here the males greatly preponderate.

Masticatory Organs:—These consist of the usual six pairs.

(1) *Mandible* (Fig. 1, F). This is a very powerful instrument adapted for cutting only (not crushing, as in some); the anterior edge being developed into a curved sharp blade-like prominence. It is furnished with a 2-jointed palp, which is fringed with fine sensory hairs.

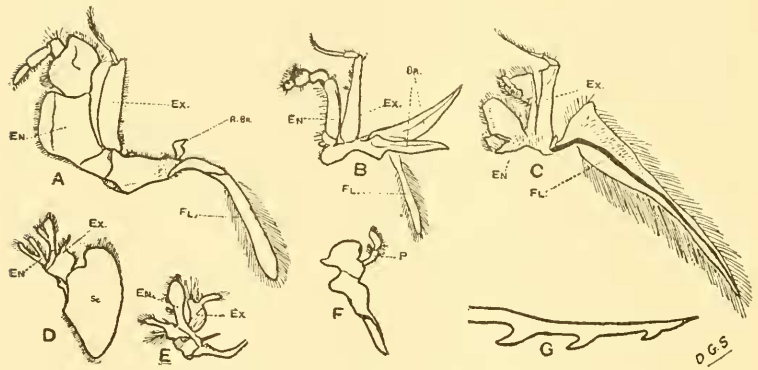

Fig. 1—*Neptunus pelagicus*.—Masticatory Organs.

A, 3rd Maxillipede; B, 2nd Maxillipede; C, 1st Maxillipede; D, 2nd Maxilla; E, 1st Maxilla; F, Mandible; G, Hooked Seta, (greatly enlarged) from Flabellum.

En. Endopodite; *Ex.* Exopodite; *R.Br.* Rudimentary Branchia; *Br.* Branchiæ; *Sc.* Scaphognathite; *P.* Mandibular Palp; *Fl.* Flabellum.

(2) *First Maxilla* (Fig. 1, E). This organ is thin, foliaceous, and rather obscurely segmented. It is apparently the most insignificant of the organs of mastication, and is fringed with setæ of a more or less bristle-like nature.

(3) *Second Maxilla* (Fig. 1, D). This has the same flattened leaf-like character as the one preceding, but differs considerably, and is more interesting to us, inasmuch as the epipoditic portion forms the *Scaphognathite* (Fig. 1, D, *Sc.*). On the upper and lower borders it is fringed with fine rather short hairs; these, I believe, are modified forms of the hairs on the epipoditic portions of the three maxillipedes, which I will presently describe.

(4) *First Maxillipede* (Fig. 1, C). This and the two following appendages may really be divided into two portions, viz., the maxillipede proper and the epipoditic portion, having two distinct functions to fulfil. When we compare this appendage with the preceding we notice that a great change has taken place. The exopodite (*ex.*) which in the second maxilla is very small, almost spine-like, becomes here greatly developed. The description given further on of the exopodite of the third maxillipede may also be applied to this case, excepting that in this appendage the exopodite is relatively larger than that of either the second or third maxillipedes, and the long undivided portion is devoid of setæ. The remaining joints of the maxillipede proper are transformed into broad thin plates, edged with setæ. The epipodite consists of a rather broad, thin, membranous lamella, gradually narrowing towards its apex, and supported throughout its entire length by a central calcified shaft. This lamella is fringed with fine hairs, described further on. Just as in the second maxilla, where the epipodite has been greatly modified to form the scaphognathite, so, in the three maxillipedes, the epipodite has been considerably metamorphosed to render it subservient to a special function, which, in this case, is that of keeping the branchial chamber and the branchiæ themselves free from particles of dirt and other impurities, and to prevent the lodgment of parasites. Judging by the amount of dirt to be found on certain parts of the walls of the branchial chambers, the gills would soon become clogged were it not for the constant action of these scrapers (for such they are) moving over their internal and external surfaces. Viewing them macroscopically, it would not perhaps be at once evident how these scrapers effect their work, but when we subject them

to a microscopic examination we find that each hair is in reality a small rake in itself, having developed towards its extremity. along one side, three or more small hook-like protuberances (Fig. 1, G). In the maxillipedes, one set of muscles serves two purposes, as, when the maxillipede proper is moved in mastication, the epipodite or flabellum being fixed to it, also moves, and then in such a manner that it sweeps the gills from bottom to top, and *vice versâ*.

In the first maxillipede this flabellum is far larger than that of either the second or third maxillipedes. It sweeps the whole of the external surfaces of the eight branchiæ, and also to some extent the internal wall of the branchiostegite.

(5) *Second Maxillipede* (Fig. 1, B). This consists of an exopodite like that of the preceding appendage; a 5-jointed, rather palpiform endopodite, of which the meros is by far the largest joint, and the podobranchia. The flabellum in this case is a slightly calcified lamella, fringed with the before-mentioned hooked setæ. This sweeps the interior surfaces of the four anterior branchiæ and the corresponding part of the body wall.

(6) *Third Maxillipede* (Fig. 1, A). This large appendage consists of a 2-jointed basal portion, a 5-jointed endopodite, a 3-jointed exopodite, and the podobranchia. The first and second joints (ischium and meros) of the endopodite are broad and massive, and are coated on their inner edges with a short red dense pubescence. The hairs which constitute this being stiff no doubt materially assist in the disintegration of food. The three remaining joints are small (they together form the "endognathal palp"), and are fringed, as also is the upper edge of the meros, with hairs of, I believe, a sensory nature. The exopodite is divided into three parts—a long, rather broad, basal portion, having strong setæ on its external border, surmounted by a very short narrow joint, this being terminated by a slender many-jointed antennary filament, clothed with very fine hairs. These two terminal joints lie across, behind the meros, at right angles to the long basal joint, and not in the position in which I

have sketched them. The flabellum is here a long somewhat oblong-ovate plate, fringed with hairs of the same nature as those before described (Fig. 1, G). The gill in this case is almost rudimentary (Fig. 1, A, *R.Br.*). It is quite obvious that even if the gill were fully developed on this podobranchia, it would be in the way, as this part has to move freely up and down, so the reason for its aborted condition is plain.

The flabellum of the second maxillipede, though serving a similar purpose to that of the third maxillipede, being very much shorter, and having to undergo far less movement, does not interfere with the accompanying gill, which, originating from its base, scarcely passes through any motion at all. The flabellum of the third maxillipede sweeps the internal faces of the four posterior branchiæ, and the adjacent portion of the wall proper of the thorax. As will be observed by referring to the diagram, the basal portion of the flabellum is devoid of the fine hooked setæ which characterise the remainder of it. This being so, the "brush" misses just in that one place. In several specimens in my possession, parasites, in the shape of tubicolous annelids, have taken advantage of this and have grown there undisturbed. This, of course, helps to prove that, were it not for these flabella the gills and walls of the branchial chamber would soon become clogged with parasites or dirt. Perhaps I may mention that not infrequently I have observed specimens in which the chelipedes and the subhepatic and pterygostomial regions also harbored parasitic annelids.

Branchial arrangement.—This is the same as that of *Cancer pagurus**, with the exception that the gill portion of the podobranchia of the third maxillipede is relatively far smaller, and in fact can scarcely be said to be more than rudimentary. The inner surface of each gill is clothed with short bristly hairs, which are here, perhaps, as an additional protection against parasites.

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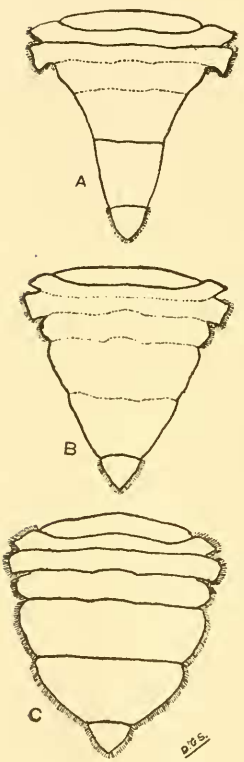
* "The Crayfish," Huxley, p. 277.

External sexual characteristics.—One of the first characteristics that is calculated to strike the casual observer in connection with the brachyurous crustacea is the difference in shape exhibited by the pleons of the different sexes. In most cases this is a sure guide to the sex, but not in all; as there are some, certain burrowing crabs, in which the structure of the pleon in both sexes is approximately the same. Here the only sure guides are the appendages, which lie concealed by the pleon (excepting a few species where the eyes of male and female exhibit some difference in shape).



The genus *Neptunus*, in common with some other genera, is characterised by three distinct types of pleon (Fig. 2).

The pleon of the male (Fig. 2, A), which is the narrowest, is composed of only five movable segments; the third being really formed by the coalescence of the third, fourth, and fifth normal segments; the sutures—which in the diagram are denoted by dotted lines—being distinctly visible. This would make up seven somites (the usual number for the crustacean abdomen). The sternal aspect of the male pleon is membranous, excepting the first segment, which is partly calcified so as to give support to the first pair of copulatory appendages.

There are two pairs of appendages attached respectively to the first and second somites of the pleon. Those chiefly concerned in reproduction, the first pair (Fig. 3, C) are divided each into two joints; the first, a thick, rather short basal portion, about one-

Fig. 2—*Neptunus pelagicus*.—Pleons.
A, Male; B, Sterile Female; C, Female.

fourth the length of the following and terminal portion which is long, styliform, and tapers to a very fine point, perforated by the ejaculatory duct. The long terminal joint is supplied with short, almost spiniform, recurved hairs in the adult male. These would, perhaps, assist the animal to keep the organs in position during copulation. As compared with the first those forming the second pair of pleopoda (Fig. 3, D) are rather insignificant.* In conformation they are somewhat similar to the former, but are more lamellate. In adult males, the end of the last joint is always found inserted into the base of the terminal joint of the first pleopod.

The female pleon, which, comparatively, is by far the largest, consists of the full number of segments, all of which are movable upon one another. It is fringed with short setæ, and is capable of such extension as to be almost in line with the carapace. The sternal aspect is chiefly membranous, but is calcified in the central portions of each of the second, third, and fourth somites, so as to give support to the large appendages (pleopoda) to which the ova are attached. In this sex, the very large ovate openings of the oviducts are situated on the sixth thoracic segment at the base of the third pair of pereiopoda, but nearer to the mesial longitudinal line.

Each pleopod consists of a small protopodite, from which depends a terminal biramous portion (endopodite and exopodite). The endopodite is rather flat, 2-jointed, and is clothed with beautifully fine, long, yellowish, silky hairs. These are distributed in great number over the two edges, and posterior aspect only of the endopodite, the anterior aspect being quite free and smooth. The posterior face is ribbed, and between the ribs the hairs are attached in regular lines. To these hairs the minute ova are attached by a gummy secretion forming a pedicle. The length of this pedicle is variable, usually wide and short, about same length as diameter of ovum, but is sometimes long and narrow. The ova, which are

* This cannot be said of all the Brachyura, as in some (*Cancer*) the second pair of pleopoda is the longer.

exceedingly numerous, average after extrusion ·4mm. in length, and ·35mm. in breadth, and are of a yellowish colour.

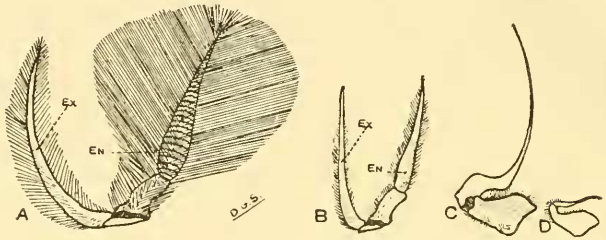


Fig. 3—*Neptunus pelagicus.*

A, First Pleopod of Female; B, First Pleopod of Sterile Female; C and D, First and Second Pleopoda (copulatory organs) of Male.

Ex. Exopodite; *En.* Endopodite.

The exopodite consists of one long joint (Fig. 3, A, *ex.*), and is clothed (on the edges only) with fine plumose setæ of a sensory nature, from one-eighth to one-fourth of an inch in length. To these hairs none of the ova are directly attached; they serve more to keep the whole mass together. The first pleopod (that figured) is the largest, and may be taken as a type of the rest, the only difference of any importance being that the exopodite becomes more lamellate in the three succeeding pleopoda.

The next type of pleon that we have to consider is—as will be seen by my diagrams—intermediate in formation, between male and female. In this form (Fig. 2, B) the pleon only consists of three movable segments, the 2nd, 3rd, 4th and 5th normal segments having coalesced, though the sutures—denoted in the diagram as before by the dotted lines—may be at once observed. The telson, like that of the male, is fringed with fine, short hairs. A noticeable feature in connection with this form is, that the pleon is not capable of extension to anywhere near the same degree as that of the male or female, so that, even if the orifices of the oviducts were large enough to admit of the passage of

ova—and they are not — fecundation could never take place owing to their inability to extend the pleon. Here the sternal aspect is chiefly membranous, though slightly calcified in the fore-part between the bases of the 1st and 2nd pairs of pleopoda. As in the male, this form possesses two hook-like protuberances on the sternal plastron, which fasten and keep the pleon in place. In the female these hooks are either rudimentary or are altogether absent. The pleon, in these sterile forms, adheres very tightly to the sternal plastron, so that some little force is required to detach it. Here the female genital orifices, though distinctly visible, are quite rudimentary. They are not perforated, though the oviducts are developed. As in the true female, there are four pairs of pleopoda (Fig. 3, B) all similarly shaped (though in this case they have undergone great modification and are considerably smaller than those of the female). The hairs clothing both exopodite and endopodite are here extremely short—almost rudimentary. Those clothing the former partake of the same plumose, sensory character as those of the same portion of the female, while those of the latter are of the same nature as the ovigerous hairs of the female. On first examining this kind some two years ago, I was led to think that, as it exhibited a good deal of resemblance to the female, it might be capable of developing into that sex through successive stages at each ecdysis; but in that case I should expect to find some connecting links between the two; this I had not been able to do, therefore I became of opinion that this form was immutable, but recently, much to my pleasure, by assiduous observation at the Woolloomooloo Fish Market, I have been able to find several specimens which I regard as approaching the female still more closely. In these the ovary was a little larger than usual (in fact, only a little smaller than that of the virgin female), the openings of the oviducts also, though still extremely small (too small for the passage of ova) were far more in evidence, the hairs on the pleopoda were considerably lengthened, and lastly the pleon was fringed with extremely short hairs. The pleon itself had not undergone much change, but this is not of very great moment. Incidentally, I might mention that one of the first things that

attracted my attention (prior to dissection) in connection with these sterile females, was, that I had never seen any signs externally of ova. There was a very good morphological reason for this, because even supposing that any ova had been extruded —and I have pointed out that this is impossible—they must inevitably have been lost, as the hairs clothing the pleopoda, though of similar structure to those of the female, are rudimentary; so that no ova could have become attached to them. The three reasons which I have already given (1st, inability to extend the pleon to allow of fecundation taking place; 2nd, rudimentary state of the vulvæ; 3rd, rudimentary state of the ovigerous hairs, conclusively demonstrate that this form *as it is** is absolutely incapable of reproduction. Here, it may be stated, that up to a fairly large size, viewed *dorsally*, it is impossible to discriminate between males, females and sterile females. After this stage is passed, the chelipeds of the male become comparatively much larger, attaining considerable proportions. The sterile females† do not become any larger, and in comparative size of chelæ and a few other general characters, resemble the female, excepting that the female's body may reach as great a size as that of the largest male.

Ten years ago, in the Proceedings of this Society,‡ Prof. Haswell described a case of *Sacculina* infesting one of our semi-pelagic species, *Nectocarcinus integrifrons*. Only male specimens were

* I emphasise "as it is" because I fully believe that this form, under certain circumstances, is capable of changing into a perfect female; in which case it would, of course, be capable of reproduction.

† Though for convenience, I have adhered to the term "sterile female," I would not be at all surprised if it should transpire that *all* the perfect females pass through this stage. Should this be so (and it can only be verified by examining a great many specimens of a very small size), the term would need to be altered to "immature female." Notwithstanding this, I consider it by no means certain that all of these forms would undergo that change, as I have found some of them considerably larger than the smallest ovigerous female.

‡ P.L.S.N.S.W. (2), Vol. ii. 1888.

affected, the pleon bearing some resemblance to the female. The appendages of the pleon in this case were wanting, those of the male being rudimentary. As will be at once perceived, the two cases are quite different, as in *Neptunus* the males are never affected, and the appendages, though modified, are never rudimentary; in fact, I have only found a very few isolated examples of the male pleon being at all malformed; and in these it was apparently due to some slight mutilation of the terminal segments. Here, the pleons bore no resemblance to those of the females or the sterile forms, the malformation merely consisting of an abbreviation of the last two segments, thus partially uncovering the first pair of pleopoda, which were in no wise affected. Prof. A. Giard, in speaking of *Sacculina* parasitic upon *Stenorhynchus phalangium*, says*: "In the infested females the influence of the parasite, which displays itself internally by the abortion of the ovules, betrays itself externally by a profound modification of the four pairs of ovigerous feet. These are very inferior in size to the normal state." Now, though the latter part of this agrees with the present case, in *Neptunus* the sterile form possesses an ovary, seminal receptacles and oviducts similar in appearance to, though smaller than, those of the female. The same authority continues: "All these modifications are produced in a more or less complete fashion, according as the crab has been infested at a more or less advanced age." That this does not apply to the present case will be at once evident, when I state that, in specimens that I have examined ranging from 1 inch to about 5 inches in diameter (including lateral spines) the pleon of the smallest exhibited these modifications in just as marked a manner as the largest, and I have never been able to discover any signs either of *Sacculina* or any other parasite.

I have merely quoted these two cases of parasitism to show that in the present instance it is not produced by the same causes. De Haan (Fauna Japonica) figures several species which possess these

* "Parasitic castration and its influence upon the male sex in the Decapod Crustacea." Ann. Mag. Nat. Hist., (5) Vol. xix. pp. 325-345, 1887.

three types of pleon. He styles them:—Males, females, and "spurious females." Some later writers, taking into consideration the already cited case of *Stenorhynchus phalangium*, have taken it for granted that the conclusions arrived at there would apply equally as well to all of the species in which three types of pleon obtain; but, as I have shown, they cannot be applied to the form under consideration.

In the foregoing remarks I have, as before stated, only referred to the genus *Neptunus*, but I feel sure that others amongst our native genera will be found to possess these sterile females. At present there are two species which I have good reason to believe agree in this manner with *Neptunus*, viz., *Ozius truncatus* and *Platyonychus bipustulatus*. The former lives among loose stones in rocky situations, whilst the latter, though really pelagic, spends most of its time half buried in the sand in shallow water.

I here desire to tender my sincere thanks to Mr. Jas. P. Hill, Demonstrator of Biology, for some kindly criticism during the course of my work; also to my friend, Mr. R. Grant, Physiological Laboratory, University of Sydney, for assistance most willingly rendered in various ways; and lastly, to Mr Whitelegge, Australian Museum, for assistance with the literature relating to the subject.